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## LIST OF ABBREVIATIONS

ADC	- Analog Digital Converter
AWR	- Microwave Office
COMSOL	- Multiphysics Finite Element Analysis Simulation Software
ESN	- Electronic Serial Number
FDM	- Finite Difference Method
FDTD	- Finite Difference Time Domain
FEM	- Finite Element Method
HFSS	- High Frequency Structure Simulator
MATLAB	- Math Lab
MIC	- Microwave Integrated Circuits
MIN	- Mobile Identification Number
MOM	- Method of Moment
MTSO	- Mobile Telephone Switching Office
RL	- Return Loss
SID	- System Identification Code
TM	- Transverse Magnetic
VSWR	- Voltage Standing Wave Ratio



## LIST OF SYMBOLS

$\lambda_0$	- Wavelength
$^\circ$	- Degree
$\epsilon_r$	- Dielectric constant
$\tan\delta$	- Loss tangent of the dielectric
$L$	- Length of the patch
$W$	- Width of the patch
$L_0$	- Length of the feed line
$W_0$	- Width of the feed line
$L_g$	- Length of the inset feed
$W_g$	- Width of the inset feed
$W_{eff}(0)$	- Static effective width
$W_{eff}(f)$	- Actual width of patch
$L_e$	- Actual length of patch
$E_\theta$	- Electromagnetic Plane
$E_\phi$	- Electric Plane
$J_i(x)$	- $i^{\text{th}}$ order Bessel Function of the first kind
$U_i(x)$	- $i^{\text{th}}$ order Bessel Function of the second kind
$Y_m$	- Mutual admittance between the radiating slot
$Y_s$	- Self admittance of the radiating slot
$Y_0$	- Characteristic admittance
$Y_{in}$	- Input admittance
$Z_0$	- Characteristic impedance
$Z_{in}$	- Input impedance
$Z_L$	- Load impedance
$R$	- Resistance

$G$	- Conductance
$L$	- Inductance
$C$	- Capacitance
$R_{in}$	- Input resistance
$X_{in}$	- Input reactance
$\Gamma$	- Reflection Coefficient
$S_{11}$	- Return loss in negative sign
$BW_{broadband}$	- Bandwidth in broadband
$BW_{narrowband}$	- Bandwidth in narrowband
$f$	- Frequency
$f_r$	- Resonant frequency
$f_L$	- Lower frequency
$f_H$	- Higher frequency
$f_C$	- Center frequency
$h$	- Substrate thickness
$t$	- Thickness of the metal
$\epsilon_{eff}$	- Effective permittivity of substrate
$\epsilon_{eff}(0)$	- Static effective relative permittivity
$\epsilon_{eff}(f)$	- Frequency dependent effective relative permittivity
$\alpha$	- Attenuation constant
$\beta$	- Phase constant
$\gamma$	- Propagation constant
$\vec{E}$	- Electric field intensity
$\vec{B}$	- Magnetic flux density
$\vec{D}$	- Electric field density
$\vec{H}$	- Magnetic field intensity
$\vec{J}$	- Current density
$\rho_v$	- Volume charge density
$c_0$	- Speed of light in free space
$d$	- Diameter of probe
$\xi$	- Euler-Mascheroni constant

$\mu_0$	- Permeability in free space
$\varepsilon_0$	- Permittivity in free space
$\sigma$	- Conductivity
$\Delta L$	- Extended length due to fringing effect
$\Delta \ell$	- Extended length due to fringing effect
$\eta_0$	- Intrinsic impedance of free space
$k_0$	- Wave number in free space
$G_s$	- Self conductance
$B_s$	- Self susceptance
$G_m$	- Mutual conductance
$B_m$	- Mutual susceptance
$C_e$	- Euler's constant
$\sigma_s$	- Conductance of the patch
$\sigma_g$	- Conductance of the ground plane
$\Delta_s$	- Rms surface roughness of the patch
$\Delta_g$	- Rms surface roughness of the ground plane
$j$	- Complex number
$si(x)$	- Sine integral of $x$
$Q_T$	- Total antenna quality factor
$Q_d$	- Quality factor of the dielectric
$Q_c$	- Quality factor for conductor
$Q_r$	- Quality factor for radiation
$\omega_r$	- Angular resonant frequency
$W_T$	- Total energy stored in the patch at resonance
$P_d$	- Dielectric loss
$P_c$	- Conductor loss
$P_r$	- Power radiated from the patch
$\Delta$	- Skin depth of the conductor
$\bar{\bar{G}}$	- Dyad
$\mathbf{E}(\mathbf{r})$	- Vector electric fields at $\mathbf{r}$
$\mathbf{H}(\mathbf{r})$	- Vector magnetic fields at $\mathbf{r}$
$\mathbf{J}(\mathbf{r}')$	- Vector source current distributions

$\mathbf{M}(\mathbf{r}')$	- Vector source current distributions
$\mathbf{E}_{le}(\mathbf{r}, \mathbf{r}', \mathbf{J}(\mathbf{r}'))$	- Vector electric fields at $\mathbf{r}$ radiated by the electric vector impulsive current
$\mathbf{E}_{lm}(\mathbf{r}, \mathbf{r}', \mathbf{M}(\mathbf{r}'))$	- Vector electric fields at $\mathbf{r}$ radiated by the magnetic vector impulsive current
$\mathbf{H}_{le}(\mathbf{r}, \mathbf{r}', \mathbf{J}(\mathbf{r}'))$	- Vector magnetic fields at $\mathbf{r}$ radiated by the electric vector impulsive current
$\mathbf{H}_{lm}(\mathbf{r}, \mathbf{r}', \mathbf{M}(\mathbf{r}'))$	- Vector magnetic fields at $\mathbf{r}$ radiated by the magnetic vector impulsive current

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